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A Summary of Current Program and
Preliminary Report of Progress

TOBACCO RESEARCH

of the

United States Department of Agriculture
and related work of the
State Agricultural Experiment Stations

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs. The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

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ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

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ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

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SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

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13 - Tobacco

A copy of any of the reports may be requested from James F. Lankford, Executive Secretary, Oilseed, Peanut and Sugar Crops Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250

Introduction

This annual report deals with research on all types of tobacco. However, it does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only tobacco problems, but also to the problems of other commodities. Progress on cross-commodity work is found in the organizational unit reports of the several divisions.

The report covers Farm Research ; Nutrition, Consumer, and Industrial Use Research; and Marketing and Economic Research. As shown in the table of contents, there is a breakdown of the research program by problem areas.

For each area, there is a statement of (1) the Problem, (2) USDA and Cooperative Program, (3) Program of State Experiment Stations, (4) a summary of Progress during the past year on USDA and Cooperative Programs, and (5) a list of Publications resulting from USDA and Cooperative Programs.

Research on tobacco crops is supported by (1) Federal funds appropriated to the research agencies of the U. S. Department of Agriculture, (2) Federal and State funds appropriated to the ten State Agricultural Experiment Stations and Puerto Rico, and (3) private funds allotted to research carried on in private laboratories or to support of State Station or USDA work.

Research by U.S.D.A.

Farm Research in the Agricultural Research Service comprises investigations on breeding and genetics, culture, variety evaluation, diseases, insects, and crop harvesting, handling operations and equipment, and curing. It is carried out in the following divisions: Crops, Entomology, and Agricultural Engineering. The work involves 41.9 professional man-years of scientific effort.

Nutrition, Consumer and Industrial Use Research in the Agricultural Research Service deals with the chemical and physical properties of tobacco leaf and the chemical composition of smoke. This work is done at the Eastern Utilization Research and Development Division, at Wyndmoor, Pennsylvania. The work involves 10.7 professional man-years of scientific effort.

Marketing and Economic Research is done in two services. Marketing research in the Agricultural Research Service deals with the physical and biological aspects of assembly, packaging, transporting, storing, and distribution from the time the product leaves the farm until it reaches the ultimate consumer. Economic research conducted in the Economic Research Service deals with market structure, practices and competition; product quality; margins, costs, and efficiency; supply and demand; and outlook and situation. The work reported herein is done by the following divisions: Market Quality, Marketing Economics, and Economics and Statistical Analysis. The tobacco research in the marketing and economic research area involves 8.4 professional man-years of scientific effort.

Interrelationships Among Department, State and Private Research

A large part of the Department's research is cooperative with the State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the Stations. Cooperative work is jointly planned, frequently with the Stations. Cooperative work is jointly planned, frequently with the representatives of the producers of industry participating. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators, which frequently includes resources contributed by interested producers or industry.

Including both cooperative and State Station projects, tobacco research is carried on by ten of the fifty-three State Agricultural Experiment Stations and in Puerto Rico. The types of work to which the largest amount of effort is devoted include breeding and genetics, diseases, variety evaluation, plant culture, and weed control. There is a regular exchange of information between Station and Department scientists to assure that the programs complement each other, and to eliminate all unnecessary duplication.

Research by industry is sponsored primarily by the cigarette and cigar manufacturers, chemical companies, and machinery manufacturers. All of the tobacco companies conduct vigorous and diverse programs designed to improve the quality of the product and reduce manufacturing costs. These companies are also studying new methods for producing "homogenized tobacco leaf" or "sheet tobacco" for cigarettes or cigar binders or wrappers; development of new tobacco varieties and related organic problems, and chemical composition of leaf and smoke. The tobacco companies work depends considerably upon discoveries resulting from fundamental work by public agencies.

Research by chemical companies is concerned with the development of new tobacco flavoring agents, cigarette paper and filters, chemical for agronomic use, "sheet tobacco" process, and new and improved machinery for manufacturing tobacco products. The Department and other public agencies continue to provide much of the basic data needed to carry out these programs.

The manufacturers of chemicals for disease control and plant growth regulation continue to expand their efforts to produce new products and introduce them into use. The Federal Government assists in this area in the evaluation of new plant growth regulators and their effect on quality.

Basic research done by the Department and States will be utilized by industry and other organizations in their research programs, especially in the further development of improved products and equipment. Industry's cooperation in supporting tobacco research at Federal and State Stations has contributed greatly to its success.

I. FARM RESEARCH

TOBACCO CULTURE, BREEDING, DISEASES, AND VARIETY EVALUATION

Crops Research Division, ARS

Problem. Production of tobaccos meeting use and economic requirements is becoming increasingly difficult and complex. Producers are constantly confronted with changing practices designed to reduce or eliminate production hazards and increase profits. New disease-resistant varieties often require exacting management for top quality and yield. Progressive developments with fungicides, fertilizers, growth regulators, and other chemicals demand extreme caution in their usage in tobacco culture. High levels of specific toxicity at low concentrations among these chemicals often necessitate adoption of exacting practices and long-range planning by the tobacco farmer in order to maintain usable characters in the cured leaf at a profitable production cost.

Smoking and health problems have recently been brought into focus before all segments of the tobacco industry, as well as the consumer. Immediate attention should be directed toward remedial measures by all concerned. An accelerated, well-coordinated research program in the areas of (1) production, (2) manufacturing, and (3) use-effects would seem to offer the greatest promise of partial to complete elimination in a minimum of time of any health hazards in tobacco usage. In recent months considerable attention has been given to orientation of the research program in tobacco production to include health related problems.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-range program involving basic and applied research on flue-cured, burley, Maryland, dark air-cured, dark fire-cured and cigar types of tobacco. Each type has rather specific quality characteristics which govern its usefulness in domestic and foreign trade. Use value of different types of tobacco is related to inherent genetic factors; however, production practices, including the area in which it is grown, have a major role in maintaining types and in establishing useful characters within a type. Both basic and applied research efforts are directed toward adapting and improving the tobacco plant and production practices to cope with production hazards, increasing labor costs, mechanization, and changing use requirements.

Research work is in progress on all domestic tobacco types in the various production areas with close cooperation of the Agricultural Experiment Stations in the following States: Connecticut, Florida, Georgia, Kentucky, Maryland, North Carolina, Pennsylvania, South Carolina, Tennessee, Virginia,

West Virginia, and Wisconsin. Cooperation with industry is as follows: Brown & Williamson Tobacco Corporation; Liggett & Myers Tobacco Company; Philip Morris, Inc.; P. Lorillard Company; R. J. Reynolds Tobacco Company; The American Tobacco Company; The Imperial Tobacco Company of Great Britain and Ireland; Bayuk Cigars, Inc.; General Cigar Company, Inc.; Consolidated Cigar Corporation; Cullman Bros., Inc.; American Sumatra Tobacco Corporation; and Cigar Manufacturers Association of America, Inc.

The Federal scientific effort devoted to research in this area totals 31 professional man-years. Of this number 8.1 are devoted to breeding and genetics; 3.4 to diseases; 3.2 to variety evaluation; and 16.3 to culture-physiology.

No lines of work were terminated during the reporting period.

PROGRAM OF STATE EXPERIMENT STATIONS

Scientists of the State Experiment Stations are engaged in basic and applied research in plant breeding and genetics, plant pathology, plant physiology, agronomy and chemistry. In many of the States, the research is conducted cooperatively with the Department. This research is continuing to provide useful fundamental information for the improvement of tobacco production.

The cultural and management studies on tobacco range from management of seed beds, growing the crop, harvesting it, and curing the leaf. The use of fumigants, rates of fertilizers, irrigation, rotation, spacing, topping, and control of suckers are being evaluated for their effects on yield and smoking quality. Hydroponic production of wrapper type tobacco is being studied in Puerto Rico. Various harvesting and curing techniques are being explored. Some of them are associated with mechanized harvest of tobacco.

The major emphasis in breeding is for improved resistance to diseases such as blue mold, black shank, wildfire, root rot and mosaic. In some instances interspecific crosses are being used to obtain the desired factors for disease resistance. Resistance to nematodes is also necessary to meet the root rot-nematode complex. Other objectives of breeding are yield, smoking quality and specific levels of nicotine and alkaloid content. The nature of heritable variation of tobacco is being studied to determine the relative efficiency of alternative breeding procedures. Other genetic studies concern abnormalities, comparative cytogenetics and genes controlling quality constituents of various Nicotiana species.

Much attention is given to smoking quality determination of varieties and tobacco subjected to a wide range of management practices. The more basic studies concern objective methods for determining smoking quality, the chemistry of curing, fermentation processes to produce specific types of tobacco leaf, and the measurement of physical properties.

The total research effort on tobacco is approximately 39.7 professional man-years; of which 5.2 is for culture, 18.5 for breeding and genetics, 4.1 for diseases, and 11.9 for variety evaluation.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Advanced Generation Flue-cured Breeding Lines. Compared with check varieties Hicks and NC 95, line 2512 produced acceptable yields in the North Carolina official variety tests, had good chemical composition and physical appearance, and had high resistance to black shank, fusarium wilt, and root knot nematodes. This line is a promising variety candidate. Another line, NC 4001 compared well with the check varieties for yield and quality, had good black shank resistance, and will be tested extensively in 1964.

Six flue-cured breeding lines were selected for advanced testing in 1964 from 150 tested in 1963 at Florence, South Carolina. Yields of some lines were equal to NC 95. Although the yield of other lines was lower, they were judged better than NC 95 in value per cwt. The chemical constituents of most of the lines compared favorably with Hicks, and none were off-flavor. All of these lines have high black shank and Granville wilt resistance. Progeny from a cross with NC 95 and a root knot-resistant line was entered in the regional minimum standards trials in 1963 as line PD 406. PD 406 is tolerant to brown spot, highly resistant to root knot and fusarium wilt, and moderately resistant to black shank and Granville wilt. Yield, quality evaluation, chemical analysis, and smoking tests qualified this entry for further testing.

2. Advanced Generation Burley Breeding Lines. Four experimental burley lines having high resistance to wildfire, mosaic, black root rot, and fusarium wilt were compared in single replications with Burley 21 and Ky. 12 at 12 locations in Kentucky. They were also grown in replicated plots with standard varieties at Lexington, Kentucky. Experimental 42 compared favorably with Burley 21 in maturity and quality of leaf, and yielded well.

About 200 burley breeding lines were tested for resistance to black shank, black root rot, wildfire, mosaic, and fusarium wilt, and for yielding ability, quality, and other agronomic traits in the Greeneville, Tennessee area. Most of the breeding lines were stabilized for *N. debneyi* factor for black root rot resistance. One of them, Gr. 49A, offers promise of release as a variety in the near future.

3. F_1 Hybrids in Flue-cured and Burley Tobacco. Studies at Florence, South Carolina showed that male-sterile tobaccos with petaloid anthers and stigma protruding above the lips of the corolla were easier to hand-pollinate

and, consequently, the most economical type to use in the production of F_1 hybrids. Attempts were made to produce hybrid seeds by alternate planting of pollen-fertile tobacco in rows with male-sterile plants, but the yield of seed was too low to have practical value.

In general, yields of flue-cured F_1 hybrids at Florence, South Carolina, were intermediate between the parents or equal to that of the better parents. Average values per cwt. were also intermediate or about the same as for the best parents, except the following hybrids which had higher average prices than either parent: Coker 316 x NC 75, Coker 316 x Vesta 5, NC 75 x Vesta 5, Coker 139 (mosaic-resistant) x SC 58, Coker 139 (mosaic-resistant) x Vesta 5, NC 95 x SC 58, NC 95 x Vesta 5, and Vesta 5 x PD 501.

A group of 8 F_1 hybrids between Greeneville 45 (a breeding line with N. debneyi resistance to black root rot) and Burley 1, 21, 37, Ky. 16, and Judy's Pride were grown on soil heavily contaminated with the black root rot parasite near Waynesville, North Carolina. Compared with parent material, all of the burley F_1 hybrids exhibited excellent resistance to black root rot and gave satisfactory yields; however, acceptability of these F_1 hybrids for cigarette manufacturing is unknown at this stage.

4. Gamete Selection. Individual plants within an F_2 population of Golden Wilt x 383-1 were crossed with a single plant of Coker 316 in 1962, and the F_1s grown in a greenhouse during the winter at Oxford, North Carolina. Field plantings in 1963 revealed that individual plants in the segregating F_2 population when combined with the relatively constant gametic source produced progenies that were measurably different. Some progenies were promising from the standpoint of nicotine content and other characteristics.

5. Pollen Preservation. Anthers which had dehisced and were at the stage of maturity normally considered optimum for hand pollination were placed in gelatin capsules in August 1962, at Oxford, North Carolina. The capsules were sealed in a glass jar and stored at approximately 3° C. Crosses made 14 months later (October 1963) revealed almost 100% viability in the stored pollen. Maintaining viability of tobacco pollen by storing it under refrigeration should be very helpful in tobacco breeding.

6. Outcrossing Frequency in Burley. Plants susceptible to mosaic were alternated with resistant plants at Lexington, Kentucky. Unopened flowers were tagged and the seed kept separate by pod. Three-week-old seedlings were inoculated with tobacco mosaic by spraying. Plants carrying the genetic factor for resistance were easily identified 3 days after inoculation. The frequency of outcrossing between plants ranged from 0.3 to 19%. Variation between individual pods on the same plant was from 1.3 to 36%.

7. Disease-resistant Maryland Tobacco. A breeding program designed to establish resistance to wildfire, mosaic, and black root rot in Maryland tobaccos is advancing. Nicotine-nornicotine ratio was determined for 318

individual plants, and those with high nornicotine content were eliminated. None of 28 breeding lines exceeded the best variety in the test (Wilson) in smoke aroma, but some were equal to, or exceeded Catterton in aroma. In variety tests at 2 locations 2 breeding lines produced significantly better quality of cured leaf than the variety Wilson. Yield of line 63-7, which had the highest grade quality, was similar to the yield of Wilson.

8. Wisconsin Cigar-binder. The Wisconsin breeding line 503 resulting from a cross of Havana 501 and Burley 21 shows promise of producing good quality binder leaf usable in manufacturing cigar-binder sheet. Line 503 has good growth characteristics and is resistant to mosaic and wildfire. The line compares favorably in yield and quality to the standard varieties Havana 501 and Havana 142.

9. Cuban Cigar-filler Varieties. Among Cuban varieties T.I. 1375 had the best burn aroma in the Pennsylvania tests. Nicotine content, ammonia equivalent, and water soluble acids of fermented leaf were lower for T.I. 1375 than for the other 3 varieties tested. In Wisconsin, plant populations of Cuban varieties T.I. 1373 and T.I. 1376 were varied to give 9002, 11,616, and 15,101 plants/A. Yields were 1,002, 1,294, and 1,507 lbs/A, respectively, for the three spacings. T.I. 1373 produced about 200 lbs/A more leaf than T.I. 1376. Side dressings of 30 and 60 lbs/A nitrogen did not increase the yield. Delaying the harvest from 20 to 30 days after topping increased yields about 130 lbs/A.

10. F_2 Populations of Dark Tobacco. Dark air-cured and fire-cured breeding lines were grown in soil heavily contaminated with the black root rot parasite and were inoculated with wildfire and mosaic at Lexington, Kentucky. Backcrossing to standard varieties and combination crosses were made to improve type and quality and combine disease resistance. Several of the lines are resistant to mosaic, black root rot (from N. debneyi), and wildfire (from Burley 21). Line DEX7 offers promise as a variety release.

11. Radiofrequency Effects on Seeds. Treatment of dormant tobacco seeds with energy from an rf electronic power oscillator resulted in reduced seed viability, morphological changes, and alterations in germ plasm in tests at Beltsville, Maryland. Morphological aberrations were not necessarily associated with chromosome irregularities. However, chromosome irregularities were noted in aberrant plants and in plants of normal appearance, but only plants with irregular chromosome behavior produced a high number of aberrant seedlings. Increased heritable changes in tobacco plants following treatment with rf electric fields show that this technique can induce genetic alterations.

12. Tumor Producing Hybrid. The interspecific hybrid Nicotiana glauca x N. langsdorffii produces an abundance of tumorous tissue. Cytological studies at Beltsville, Maryland revealed a variable number of chromosomes in the tumor cells. Evidence indicates that chromosome loss was an important factor in the transition of normal cells to tumorous cells. Tumorous tissues

were found to be different from normal parental tissues in levels of alkaloids and organic and amino acids. Tumors had higher contents of phenolic compounds, scopolin, and scopoletin in comparison with normal parental tissues.

B. Diseases

1. Halogen Accumulation Studies in Soil. A 12-year experiment was completed at Tifton, Georgia, in which field plots devoted to continuous tobacco culture were fumigated yearly with a dichloropropene-dichloropropane mixture (D-D) and 40% ethylene dibromide (EDB-40) to investigate possible accumulation of chlorine and bromine residues which might be taken up by the tobacco plant. One-half of each plot was irrigated when necessary, while the other one-half was not irrigated. Supplemental irrigation and seasons with ample rainfall compared with no irrigation and seasons with low rainfall reduced the halogen content of cured tobacco. The evidence obtained indicates halogens did not accumulate after 12 continuous years of fumigation with D-D and EDB-40.

2. Greenhouse Disease Tests. A series of 20 tobacco varieties and 46 advanced breeding lines were subjected to critical evaluation of resistance to bacterial and fusarium wilts in North and South Carolina. The disease-producing organisms were grown on artificial media and used to inoculate individual plants of each variety and breeding line under greenhouse conditions. The same entries also were included in tests for resistance to black shank and the root knot nematode. The indices for each disease were combined with similar data obtained from Georgia and Virginia. Thirty-three of 36 breeding lines tested had a moderate or higher level of resistance to black shank, but only 5 of the 36 lines also had a similar level of resistance to bacterial wilt and fusarium wilt.

3. Root Knot Nematode Resistance. Previous research has established that certain flue-cured breeding lines and the variety NC 95 are resistant to root knot caused by Meloidogyne acrita, but are susceptible to M. javanica. The latter species occurs in Georgia and Florida, but is rarely found on tobacco in the Carolinas. In a study at Florence, South Carolina, Hicks was about equally injured by M. acrita and M. javanica and showed yield depressions up to 300 lbs/A as compared with uninoculated controls. Breeding line 410 and variety NC 95, which are resistant to M. acrita, showed considerable resistance to M. javanica, although some galling developed.

4. Pre-transplant Soil Fumigants. Five chemicals were tested for possible inhibitory action on the black root rot parasite at Waynesville, North Carolina. A planting of Burley 21 was completely destroyed in 1962 in the field selected for the study. In 1963, the treatments chloropicrin + Vidden-D (dichloropropene and dichloropropane mixture) and propargyl bromide + Vidden-D substantially reduced root injury from the black root rot parasite. Reduced injury resulted in increases in yield of 1466 and 1137 lbs/A, respectively, in comparison with the untreated plots.

5. Resistance to a Virulent Strain of Pseudomonas tabaci. Forty-seven species of Nicotiana were tested in the field at Beltsville, Maryland, and N. arentsii, N. glauca, N. rustica var. pavonii, and N. undulata gave evidence of resistance to the virulent strain by lack of necrosis when wound inoculated. In both field and greenhouse tests N. arentsii exhibited resistance by lack of necrotic reaction.

C. Quality and Varietal Evaluation

1. Response to Nutrients. In 1963 twenty flue-cured varieties were grown at Florence, South Carolina, in relatively disease-free soil fertilized at 1,200, 1,600, and 2,000 lbs/A of 4-12-12. Although the crop was destroyed by a hail storm after the third priming, the yield of cured leaf from the bottom of plants showed a sharp delay in rate of maturity from increased fertilization in some varieties and little to none in others.

In tests at Lexington, Kentucky, striking differences in the uptake of potassium and calcium were found among certain burley varieties and breeding lines. Such information should be of much value in breeding programs and in adjusting fertilizer rates to the needs of individual varieties and breeding lines.

2. Chemical and Physical Properties Affected by Fertilizer. Substitution of potassium nitrate for ammonium and potassium sulfates at Tifton, Georgia, significantly increased acre yields and values of the cured leaf (more than 20%), and increased the total amount falling in the better U. S. standard grades. A marked reduction in sulfur content, striking improvement in burning properties, increased filling capacity, and lowered sugar content in the cured leaf were associated with the substitution of potassium nitrate for ammonium sulfate and potassium sulfate.

3. Fertilizer Rates. Three widely used varieties (Hicks, NC 95, and McNair 12) and one discount variety (Coker 316) of flue-cured tobacco were compared at four rates of 4-8-12 fertilizer with and without irrigation at Tifton, Georgia. Significant differences were not found in the yields or values of cured tobacco produced without irrigation and that receiving two 1-inch applications of irrigation water during early June when practically no rain fell. Acre yields increased as the fertilizer rate per acre was increased from 1,000 lbs. to 2,500 lbs. in 500-lbs. increments, but at a diminishing rate. Yield responses to increased fertilizer rates were greatest with Hicks and least with McNair 12. Coker 316 and NC 95 were intermediate. Hicks had the highest value per cwt. and Coker 316 the lowest. Considering all varieties the average percentages of the total yield graded as "usable" tobacco (by leaf representatives of one tobacco manufacturer) from the various fertilizer rates ranged from 13% at the 1,500-lb. level to 33% at the 2,500-lb. rate, with a high for a single variety being 53% of NC 95 at 2,000 lbs. fertilizer per acre.

D. Culture and Physiology

1. Weed Control in Plant Beds. Fall and spring treatments with Vapam (SMDC), Vapam 2, and Mylone (DMTT), fall steaming and calcium cyanamide, and spring treatment with methyl bromide in cigar filler tobacco plant beds were studied in Lancaster County, Pennsylvania. With most treatments significant differences in weed control were not found. However, methyl bromide and Vapam 2 treatments gave better weed control than did fall-applied cyanamide and Mylone. Methyl bromide tended to control weeds better than steaming. This occurred in several previous years.

2. Plant Bed Covers. Comparisons of polyethylene and cotton cheesecloth for burley plant beds were continued at Greeneville, Tennessee, and Waynesville and Laurel Spring, North Carolina. Unseasonably high temperatures prevailed during the second week following seeding. During this period tobacco seed germinated rapidly under plastic covers and a substantial percentage of the seedlings were killed. This experience emphasizes the urgent need of further studies directed toward eliminating the hazards involved in the use of plastic covers on tobacco plant beds.

3. Nitrogen Sources for Plant Beds. $NaNO_3$ and $(NH_4)SO_4$ were compared as sources of N at rates of 4 and 8 pounds of N per 100 sq. yds. at Waynesville, North Carolina, on soils fall- and spring-fumigated with methyl bromide and covered with plastic and cheesecloth. Despite some loss of stand from high temperatures under plastic covers, results of the tests justify the following general statements: (1) Fewer plants emerged where $(NH_4)_2SO_4$ was the source of nitrogen than where $NaNO_3$ was the source. The reduction in stand with $(NH_4)_2SO_4$ nitrogen was greater on the spring-fumigated than on the fall-fumigated soil. (2) Conversion of ammonium nitrogen to nitrate nitrogen was more rapid in the fall-fumigated soil than it was in the spring-fumigated soil and was more rapid under plastic covers than it was under cheesecloth covers. (3) The seasonal yield of transplants was substantially greater in the beds fertilized with NO_3 nitrogen than it was in those fertilized with NH_4 nitrogen.

4. Date of Transplanting. Five transplantings were made at 2-week intervals beginning May 3, at Greeneville, Tennessee, in 1963. Plants grown under plastic were used for the first two settings. Although the differences were not significant, there was an increase in yield with each delay in transplanting through the third date. The yield of the fifth transplanting was about 400 to 500 pounds less per acre than were those of the earlier setting dates. All treatments produced tobacco of similar grade quality.

5. Rates of N, P_2O_5 and K_2O. Increasing the rate of nitrogen fertilizer from 120 to 220 pounds per acre resulted in increased yields and acre values of burley tobacco in Western North Carolina. Nitrogen additions above 220 pounds per acre gave no significant increases in yield. Quality, as measured by value per cwt., decreased with the application of each increment of nitrogen above the base rate of 120 pounds per acre. Acre values decreased

following the application of more than 220 pounds of nitrogen per acre. Additional P_2O_5 above the base rate of 80 pounds per acre resulted in no significant change in yields; however, there was a trend toward lower quality. The application of K_2O above the base rate of 170 pounds per acre resulted in no apparent change in acre yields, acre values, or values per cwt.

6. Nitrogen Sources and Rates. Ammonium nitrate and potassium nitrate were compared at Greeneville, Tennessee, as nitrogen sources for burley tobacco at rates of 60 and 120 pounds of N per acre. At a given rate of N, yield and quality of the tobacco did not differ significantly between the two sources. Ammonium nitrate, ammonium sulfate, sodium nitrate, urea, and potassium nitrate were compared as side-dressings for burley tobacco at 75 and 150 pounds of N per acre in middle Tennessee. Yields of tobacco with 150 pounds of N per acre were generally 100 to 150 pounds higher than with 75 pounds of N per acre. All nitrogen sources produced similar yields of tobacco when applied at the same rate of N. Grade quality of the cured leaf was not affected by the N sources used.

7. Response to N Following Vetch and Rye. The response of burley tobacco to nitrogen following a leguminous (vetch) and a non-leguminous (rye) cover crop was initiated at Greeneville, Tennessee, in 1963. Rates of N applied were 0, 75, 150, 225, and 300 pounds per acre. An additional treatment consisted of 10 tons of manure plus 75 pounds of nitrogen per acre. Average yields for all treatments following vetch were about 200 pounds more per acre than for the same treatments following rye. Significant increases in tobacco yields were not obtained by using more than 75 pounds of nitrogen after vetch or 150 pounds after rye. Ten tons of manure per acre had about the same effect on yield as the additional 75 pounds of mineral nitrogen. Considering all treatments acre values of tobacco followed a pattern similar to yields. Significant differences in grade quality among the various treatments were not found.

8. Curing Characteristics. Five advanced flue-cured breeding lines were grown at Oxford, North Carolina, and compared with Hicks variety as a check. Five replicates of each line were flue-cured in a barn with one concealed stick of Hicks as a check. Five plots of Hicks were cured in a separate barn as an additional check. Comparisons of concealed single sticks of Hicks among the breeding lines with the larger lot of Hicks cured separately was complicated by the wide difference in sample size. However, indications were that the different curing regimes did not have drastically different effects on the Hicks variety, and that the method did expose differences in the cured leaf of breeding lines when compared with Hicks. Evaluation by each priming offers promise of locating stalk positions on breeding lines yielding poor, medium, or good quality leaf in comparison with a standard variety.

9. Chemical Weed Control in Flue-cured Tobacco Fields. Tillam (propyl ethyl -n-butylthiolcarbamate), Dacthal (dimethyl 2,3,5,6-tetrachloroterephthalate), and Trifluralin (alpha, alpha, alpha-trifluoro-2, 6-dinitro-N, N-dipropyl-p-toluidine) were incorporated into the soil just prior (about 6 hours) to transplanting tobacco at Tifton, Georgia. Diphenamid (N, N-dimethyl-2, 2-diphenylacetamide) and one additional treatment with Dacthal were applied, one day after transplanting, to the surface of the soil and plants. The test was designed so that all herbicides were compared in plots which were cultivated but not hoed and in other plots with no cultivation or hoeing. Index values (1= no weed control; 10= perfect weed control) were calculated for each plot 4 weeks after transplanting. Index values for Diphenamid and Trifluralin ranged from 8.4 to 9.4, and for Tillam and Dacthal they ranged from 7.2 to 8.9, with lower values usually associated with the non-cultivated plots. These values were about the same as those for control plots hoed and cultivated. Post-transplant application of Dacthal was unsatisfactory. Values of 7 or less were considered unacceptable. Yields and values of cured tobacco from the chemically treated plots generally equalled or slightly exceeded those from most of the control treatments.

10. Chemical Weed Control in Burley Tobacco Fields. Diphenamid, trifluralin, dacthal and tillam were evaluated for weed control in burley tobacco at three locations in Western North Carolina. All chemicals were applied either as a post-transplant spray or incorporated into the soil pre-transplant. Field observations and yield data indicate that burley tobacco was tolerant to all herbicides evaluated except dacthal applied post-transplant to the surface and trifluralin, which was incorporated into the soil at 1 pound per acre. In general, all herbicides were more effective in controlling grasses than they were in controlling annual broad-leafed weeds. The most prevalent weeds not effectively controlled were morning-glory, hairy galinsoga, nicandra and, in some cases, barnyard grass. Except for these weeds, moderate to good control was obtained from diphenamid, trifluralin, dacthal, and tillam. Similar results were obtained with diphenamid at Greeneville, Tennessee. Trifluralin, eptam (ethyl N, N-di-n-propyethial carbamate) and tillam were either toxic to tobacco or did not control weeds satisfactorily.

11. Pathways of Alkaloid Formation. In an effort to determine if nornicotine can serve as a precursor to nicotine radioactive labeled methionine and N^{15} labeled nornicotine were supplied to tobacco plants through the roots. N^{15} excess and C^{14} activity were found in nicotine isolated from these experimental plants. Methyl-C^{14}, known to be very active biologically, was incorporated at a higher rate than N^{15} - nornicotine except in an early stage in the root where there was a high relative incorporation of N^{15} in nicotine. The general relative incorporation of N^{15} - nornicotine and methyl-C^{14} from methionine to nicotine, however, is very similar in the root and shoot. The main site of methylation, starting from four days after supplying plants with the various materials was in the tobacco shoot. Results from this study indicate that nornicotine can serve as an immediate precursor of nicotine. Fifty-four elements were added singly and in various combinations to culture solutions supporting growing tobacco plants for

possible effects on alkaloid accumulation in the plants. Preliminary results indicate sharp increases in total alkaloids were associated with additions of mercury, palladium, and silver; slight increases with additions of gold, rodium, zinc, sodium, and lanthanum; sharp decreases with additions of vanadium, nickel, cobalt, and iodine; and slight decreases with additions of arsenic, thorium, neodymium, rubidium, and platinum.

12. Site of Alkaloid Synthesis. The influence of stock and scion on alkaloid synthesis and transformation in Nicotiana sp. and related plants has been studied at Beltsville, Maryland. Reciprocal grafts of different combinations of plants were made including Licopersicon esculentum Mill cv. Rutgers; Nicotiana tabacum L. cv. Maryland Robinson Medium Broadleaf, a nornicotine strain; cv. Swarr-Hibshman, Pennsylvania cigar-filler; cv. Baur, a low nicotine tobacco; N. glauca Grah.; and N. glutinosa L. The top of tobacco plants grafted onto tomato stock produced an appreciable amount of alkaloids, indicating the capability of alkaloid synthesis in a scion in the absence of its own roots. Nicotine was absent in grafted plants composed of tops of N. glauca as scion, but nornicotine was always present. Nornicotine predominant plants, N. glutinosa and Maryland Robinson tobacco, were dependent on both root and shoot to produce a normal level of nornicotine.

13. Influence of Environment on Sucker Control. Sucker growth on burley was compared in controlled-environment chambers at Lexington, Kentucky, under 8- and 18-hour light periods at 30° C followed by 20° or 30° C nights. Sucker growth was greatest under the long days followed by warm nights, and least under short days with cool nights. Sucker growth in all lots treated with fatty acid derivatives was less than for the non-treated controls in the corresponding environment. Plants that were moved to high humidities immediately after spray application of the fatty acid derivatives developed less sucker growth than those moved to low humidities.

14. Growth in Controlled Environments. Five varieties of tobacco from three general latitudes of adaptation (1 from Wisconsin, 3 from Kentucky, and 1 from the Caribbean) were grown together at Lexington, Kentucky, under 4 programed environments. Variables were photoperiods (8- or 18-hours) and night temperatures (20° or 30° C). Shorter and longer than natural photoperiods were used to bring out extremes in photoperiodic responses. Most rapid initial growth for all varieties tested was in the 18-hour, 30°/30° chamber. Night temperature did not alter time of flowering within a variety on 18-hour days. However, low night temperature hastened flowering of all lots on 8-hour days. Response of burley plants was most pronounced. They remain vegetative on 18-hour days with 20° or 30° C nights. But they flowered as early as other varieties on 8-hour days with 20° C nights. Plants on long days developed thick, coarse-textured leaves.

15. Phosphorus Deficiency Causes Leaf Spot. Work now in progress at Lexington, Kentucky, has shown that the leaf spotting of two varieties (L-8 and Burley 37) is greatly increased by low levels of phosphorus in the nutrient culture, while other varieties (Burley 21, Ky. 10, Ky. 12 and

Ky. Exp. 4) do not show any leaf spotting at the same levels of phosphorus. Comparisons have been made of the inorganic phosphorus, acid labile phosphorus, and total phosphorus for L-8 (a variety highly resistant to black shank), Burley 21, and Ky. Exp. 4. Under certain levels of phosphorus in the nutrient culture, the L-8 has only about 15 percent as much inorganic phosphorus and about 30 percent as much acid labile phosphorus as the other two varieties. However, the total phosphorus content was not appreciably different. Thus, it appears that the leaf spotting is not due to a lack of phosphorus uptake, but to improper metabolism of the phosphorus in the plant.

16. Axillary Bud Development. Anatomy of the upper leaf axils of tobacco plants was studied just prior to normal topping at Raleigh, North Carolina. Three potential suckers were found in each axis, i.e., a well differentiated primary sucker attached to the main stem, a less differentiated secondary sucker attached to the upper surface of the leaf petiole, and a meristematic area outward on the leaf petiole which is potentially the tertiary sucker. The vascular system of the axillary bud complex is associated with the leaf trace. After separation from the leaf trace, the vascular systems of the primary and secondary suckers are closely associated with the former more differentiated than the latter. A provascular strand extends from the provascular tissue of the secondary sucker toward the potential tertiary sucker.

17. Sucker Control. The accelerated research program on sucker control on all domestic types of tobacco was continued in 1963, in three phases: (1) Screening of chemicals under greenhouse conditions for sucker inhibition and toxicity to tobacco plants. This program is centered at Beltsville, Maryland, with winter field tests in Puerto Rico. Acceptance of materials examined elsewhere will be the responsibility of a sub-committee appointed by the Regional Committee. During the past 3 years some 6,000 chemicals were examined in greenhouse tests. (2) Preliminary field screening of promising materials from the greenhouse tests and those accepted from other sources. (3) Final field evaluation of materials surviving the preliminary field screening will be in replicated field tests for at least a two-year period. Promising materials will be tested on all domestic types of tobacco at one or more locations in all areas of production. About 14 compounds were examined in the field on flue-cured, burley, dark-fired, and cigar tobaccos at 16 locations in 1963. Based on the results of these tests the following (coded) materials have been selected for further field testing: Flue-cured TD-248, potassium salt of maleic hydrazide and the methyl ester of C_{10} fatty acid; burley, potassium salt of maleic hydrazide and the methyl ester of C_{10} fatty acid; cigar, TD-248, USDA Cpd. No. 8174 and 2756, potassium salt of maleic hydrazide, and the methyl ester of C_{10} fatty acid; dark-fired, TD-248, potassium salt of maleic hydrazide, and the methyl ester of C_{10} fatty acid.

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TOBACCO INSECTS

Entomology Research Division, ARS

Problem. Insecticides that have proved effective for the control of insects that attack tobacco, particularly budworms, hornworms, flea beetles, and aphids, have resulted in undesirable residues on cured tobacco. Such residues adhere to the leaf through commercial processing into cigarettes and some have been found in the main-stream of smoke from commercial cigarettes. There is, therefore, need for the development of effective methods of controlling insect pests of tobacco that will not lead to insecticide residues in cigarettes or other manufactured tobacco products. This would include more intensive research on lures, light traps, sterilization, and other new approaches to control; better utilization of predators, parasites, and diseases of tobacco insects; evaluation of tobacco varieties which resist insect attack; and research for insecticides that leave no residue.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing program involving basic and applied research on tobacco insects to develop effective control methods that will not lead to insecticide residues in cigarettes or other manufactured tobacco products. The program is cooperative with State and Federal entomologists, chemists, agronomists, and agricultural engineers in the States where research is underway, and with the tobacco industry. Studies are conducted at Oxford, N. C.; Florence, S. C.; and Quincy, Fla. Work is under contract with Kentucky, North Carolina, and South Carolina Agricultural Experiment Stations, and with the Virginia Polytechnic Institute.

The Federal scientific effort devoted to research in this area totals 5.9 professional man-years. Of this number, 1.1 is devoted to basic biology, physiology, and nutrition; 0.6 to insecticidal and cultural control; 0.1 to insecticide residue determinations; 0.8 to biological control; 2.3 to insect sterility, attractants, and other new approaches to control; 0.0 to evaluation of equipment for insect detection and control; and 0.7 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

The tobacco-producing States have an active research program on tobacco insects and their control. Biological research places emphasis on seasonal history and behavior of injurious insects. Much of this work consists of evaluating the effects of environmental conditions throughout the year on population dynamics and rearing the insects in the field and laboratory. For example, in the tobacco hornworm the winter survival, length of life and factors inducing and terminating diapause are being studied. The accumulation of data on abundance and its relation to climatic factors may make it possible to predict the severity of infestations of this insect.

New insecticides, particularly those believed to be heat degraded or metabolized are being screened to determine their efficiency in controlling tobacco insects. Those materials which appear to be biologically promising are placed in advanced testing programs. Coincidentally, the fate of the residue from application through curing, aging, and smoking is studied. New application methods, particularly those which might decrease residues, are evaluated. Attempts are being made to utilize parasites, predators and disease organisms more effectively. Cultural controls under investigation include influences of crop rotation and fertilizer application on the kinds and numbers of insect pests that attack tobacco.

Research is in progress to isolate the female attractant from the hornworm moth and use it or other baits to lure the moths to traps.

Plant resistance studies entailing screening of varieties and foreign introductions are being conducted to locate factors conferring resistance to specific pests. Susceptibility to infestation is measured by comparing the reproduction of the pest involved on each variety, the relative tolerance of the plants to insect attack and general agronomic characteristics. Where resistance is observed, backcrosses and selections are made to convey the responsible factor to adapted varieties. Biochemical studies are performed to determine the chemical nature of the factor and its influences on the pest involved.

There are 5.9 man-years dedicated to research on tobacco insects by the States.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology and Nutrition

In North and South Carolina up to one third of the budworms attacking tobacco in the spring are corn earworms. In studies in Florida in 1962 and 1963 this species was not found on tobacco until after harvest in August. Early harvest of tobacco in Florida allows time for two broods of hornworms on sucker growth. In 1963 priming was completed in all fields the first week of August but suckers were present until the plants dried up in late September.

Light trap catches of tobacco hornworm moths on St. Croix, Virgin Islands, show a seasonal pattern resembling that in Florida. The numbers caught were 15 to 31 per month from April to the middle of December and one or two from December through March.

Two methods have been developed to collect large numbers of hornworms. At Florence, S. C., large fifth instar larvae were collected from tobacco fields, then fed tobacco plants in racks, and finally allowed to pupate in loose soil over wire screening. Out of 90 thousand larvae collected, about 36% were recovered as pupae. These were stored in shredded paper in cardboard

boxes in an unheated building for the winter and about 80% survived. At Oxford, N. C., moths were allowed to oviposit on cut plants and the larvae reared on cut tobacco or released in the field. The large fifth instars were collected and placed in wooden cells and kept at a high humidity. About 80-90% of these larvae were recovered as normal pupae.

Rearing studies conducted with various diets for the tobacco budworm indicate that the larvae must be isolated. A single individual can be reared in about 1 square inch of space on less than 5 grams of food. Labor in egging the moths was greatly reduced by using a cage with walls made of paper towels. The towels are drawn through the egging chamber to collect the eggs.

B. Insecticidal and Cultural Control

In field experiments at Florence, S. C., the two species of wireworms that are serious pests of newly set tobacco plants and have become resistant to most of the chlorinated hydrocarbon insecticides were not effectively controlled with parathion during 1963. This is the first season that parathion has failed to give excellent control at the recommended dosages.

At Quincy, Fla., the practice of applying chlorinated hydrocarbon insecticides plus parathion once or twice each week to shade tobacco results in very high residues on the wrapper leaf of cigars. To reduce these high residues, an experiment was set up in which the shade was planted with insect-free plants. Granular Di-Syston was applied as a preplant treatment at 4 lb. per acre for aphids. Budworms and cabbage loopers were hand picked each week. No insecticides were necessary until 5 primings had been harvested. At that time the plants were pushing up the top of the shade cloth even though it had been raised 18 inches, and budworms laid eggs on the plants through the top cloth. Two applications of endosulfan and parathion controlled these insects. A light trap inside the shade caught small numbers of budworms, corn earworms, cabbage loopers and cutworm moths.

Di-Syston at 4 lb. per acre increased the yield by about 9%. There was no apparent effect on rootknot or black shank, but the index of coarse root disease was reduced 64 to 55 according to the cooperating Florida State plant pathologist.

Cigars made from shade tobacco treated with Zectran, Di-Syston, Niagara 9203, Kelthane, and Bayer 44646 and taste tested by the American Tobacco Company were equally as good as the untreated check.

C. Insecticide Residue Determinations

Preliminary results obtained by chemists indicate that residues of DDT and endrin were higher on commercial grown shade tobacco in 1963 than they were in 1962.

D. Biological Control

At Quincy, Fla., tests were made with weekly applications of the bacterium Bacillus thuringiensis and a Heliothis virus for the control of all insects on sun tobacco without use of insecticides. The virus alone was slow in killing the tobacco budworm and gave only about 50% reduction in damage; Bacillus alone or with the virus reduced damage 75 to 80% and gave reasonably good control.

E. Insect Sterility, Attractants, and Other New Approaches to Control

At Florence, S. C., the crude extract of sex attractant which was obtained from virgin female tobacco hornworm moths was tested in field trap cages. The numbers of moths captured during one night were 18, 31, and 40 for 10, 20, and 40 female equivalents, respectively. During the early part of the season when hornworm populations were low, traps were baited with live virgin females. One female attracted as many as 38 males in 7 nights. A few were not attractive, but most of them attracted 1 to 8 males per night. Several attracted 9 to 12 and 1 attracted 17 in one night. At the same time a trap baited with 20 female equivalents of extracted material captured 6 to 20 males per night. Crude extracts were effective for only one night.

At Oxford, N. C., virgin females of the tobacco budworm, caged in a modified gypsy moth trap, attracted males. Traps baited with either extracts of whole virgin females or hexane extracts of the last two abdominal segments also caught males and were effective up to nine days when the extracts were kept in the refrigerator during the daylight hours. The maximum male response occurred just prior to dawn.

A large light trap experiment using 3 traps per square mile over 113 square miles has been conducted at Oxford, N. C. for 3 years. In 1962 the indicated reduction in hornworm numbers was about 60%. In September of that year, tobacco growers reduced the acreage of tobacco stalks on which overwintering populations of hornworms and budworms are produced by about 50%. In 1963 in a continuation of the light trap experiment, the number of hornworm eggs on tobacco in the lighted area was reduced 83% over that in the check or unlighted area. The number of insecticide applications applied by growers in the light trap area was reduced by about 90%. In September a campaign to get all of the stalks cut was more than 90% successful. Spring populations in 1964 were very low, but the indicated control was about the same as 1963.

In the above light trap area there was also some reduction in the tobacco budworm and corn earworm populations. Where traps were located in cornfields the number of ears infested by the corn earworm was reduced about 80% within 50 feet of the trap, but there was no effect at 300 feet. However, there was a general population reduction on sweet corn of about 20% within the trapped area.

Populations of other species of large moths were also reduced in the light trap area. The Plebian Sphinx was reduced from 40 per light trap outside the lighted area to 6 per trap inside, and the Luna moth from 20 per trap outside to 4 inside.

Male hornworm pupae subjected to varying dosages of gamma radiation were not completely sterilized up to 80 kr. Almost all of the pupae died when treated with 15 to 40 kr. at 7 to 15 days before emergence, but there was no significant increase in mortality or crippling between 5 and 80 kr., when the pupae were treated 8 hours to 2 days before moth emergence.

Experiments with chemosterilants showed that topical treatments of 360 ug of tepa will sterilize male hornworm moths. When males caught in light traps were marked sterilized and released, they lived almost as long as untreated males, but the life of laboratory-reared males released at the same time was shortened as indicated by recapture data.

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TOBACCO HARVESTING, CURING, AND ELECTROMAGNETIC AND ULTRASONIC ENERGY FOR INSECT CONTROL
Agricultural Engineering Research Division - ARS

Problem. The cost of harvesting tobacco with hand labor is a major expense in the cost of production. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory. Complete mechanization of the harvesting process is necessary if the United States farmer is to compete effectively on both the domestic and foreign markets.

There is a need to develop better methods, techniques, and equipment for use on farms in preparing tobacco leaf for market. Increased efficiency is needed in the use of labor and equipment in order to preserve quality and prevent damage from mechanical handling. Basic and precise information is essential to improving curing and sorting practices.

To minimize the use of possible hazardous chemicals and their residues as much as possible, there is a need for widespread investigation of non-chemical pest control methods, such as study of insect response to all possible types of radiation and sound and exploration of weak physical links in the life of particular insects.

USDA PROGRAM

The Department has a continuing long-term program involving agricultural engineers engaged in both basic and applied research on the engineering phases of crop harvesting and handling. Tobacco harvesting research is conducted cooperatively with the Experiment Station at Lexington, Kentucky.

Research on curing and sorting is also being conducted in cooperation with the Experiment Stations at Lexington, Kentucky. Efforts are being made to determine the essential practices involved in curing Burley tobacco and to develop curing systems that will maintain product quality at reduced cost and labor.

The Department has a continuing long-term program of basic and applied research involving agricultural and electrical engineers and physicists working cooperatively with USDA entomologists and with the Experiment Stations. Electrical and physical methods of tobacco insect control are being studied in North Carolina and Virginia.

The Federal scientific effort devoted to research in these areas totals 5.0 professional man-years. Of this number 2.0 is devoted to tobacco harvesting and handling operations and equipment; 2.0 to curing and sorting; .8 electric traps for tobacco insects; and .1 to radiofrequency energy treatment of tobacco seeds.

REPORT OF PROGRESS FOR
USDA AND COOPERATIVE PROGRAMS

A. Tobacco harvesting equipment

1. Handling of stalk-cut air-cured tobacco on pallet-rack curing frames. A conventional barn at the Experiment Station Farm was modified by removing one side and the first three levels of tier rails, and installing adjustable side curtains on the modified side. Thirty-six 6 x 8 x 12 feet steel portable curing frames were constructed. They were filled in the field one day after the tobacco was cut. Three bulk densities were tested; 30, 39 and 48 square inches per stalk in area of frame plan section. The frames were placed into the barn on the tenth day after cutting, being handled entirely by a front-loader tractor. Approximately 18 man-hours per acre were required for housing. Normally 40 man-hours per acre are required during conventional housing. Neither bulk density nor location within the barn had significant effects on quality of the cured product, based on government leaf graders' evaluations.

A harvesting and housing system was proposed in 1963 involving the handling of stalk-cut air-cured tobacco on vertically suspended strings. The system is to utilize a harvester whose function is to mechanically cut the stalks, automatically fasten the base of the stalks at regular intervals to a continuous twine, and convey the "chain" of stalks to a wagon pulled alongside. A portable drum hoist on a rail system at the top of the barn will be used to pull the tobacco from the wagons. Components on the harvester will be pneumatically or hydraulically driven.

Cooperation was continued with the University of Kentucky Agricultural Engineering Department toward the development of a mechanical harvester to cut unprimed tobacco plants and place them on conventional wooden sticks. A spearing mechanism using a "spiral-held floating spear" was constructed and field tested in 1963. Different shielding techniques were tested in an attempt to minimize leaf loss, which was the major problem encountered with the mechanism. This loss of leaves amounted to approximately one leaf per stalk. Improved shielding may decrease this loss by 50 percent.

Tobacco leaf resistance to external force. Engineers who establish design criteria for machines to handle tobacco must consider the plant's resistance to forces exerted by the machines. Of particular concern is the maximum force which the leaf can tolerate without injury or loss of market value. An investigation was continued to define the relationship between leaf resistance to bruising and yellowing time. Four tests were made with an attempt to eliminate or minimize all variables except time of yellowing. Resistance was found to fluctuate considerably during the first 24 hours after harvest, starting at approximately 60 p.s.i., rising to about 95 p.s.i. after 10 hours, then decreasing to 30 p.s.i. after 24 hours where it remained rather constant during the remainder of the testing period of 90 hours.

This pattern was consistent for all four tests. Additional work will be required to explain the reason for the variation in resistance.

The strength properties of tobacco stalks are important in the design of machines to handle the crop. Values for modulus of elasticity of the woody portion of the stalk were determined in 1962 for three varieties of Burley tobacco. Work is now being done to determine the applicability of these values to intact stalks. Testing techniques have been worked out for testing intact stalks in flexure to determine modulus of elasticity for comparison with values obtained from small specimens of material sawn from the woody portion of the stalk. Preliminary investigations indicate that values determined from small specimens may be applied to intact stalks.

Stage of maturity at harvest has a considerable effect on the quality of the cured tobacco. An objective means of evaluating maturity is needed by producers and by research workers in order to obtain reproducible results from experiments, especially in curing investigations. A study was made to determine the feasibility of using moisture content of the tobacco plant as an indication of its stage of maturity. Moisture contents of both stalks and leaves were taken periodically over a 4-week period beginning approximately 3 weeks before normal harvest time. Values of moisture content were plotted against time or stage of maturity and equations for the relationships between these variables were determined by regression analysis. However, fluctuations between determinations, due chiefly to rains, resulted in standard errors of estimate which would warn against using moisture content alone as an index of stage of maturity. This does not mean, however, that moisture content and one or more other variables such as soil moisture might not give a reliable indication of stage of maturity.

B. Tobacco curing

1. Certain thermal properties of tobacco during the cure. The object of this investigation has been to determine the thermal conductivity, specific heat, and thermal diffusivity of turgid tobacco during the cure. These basic "engineering" properties are needed in the analysis, design and development of facilities for controlling the environmental and curing processes of tobacco. The apparatus used was a guarded hot plate designed and constructed after ASTM specifications but with modifications to account for pertinent biological characteristics of test specimens. Each test specimen was formed from approximately 25 to 75 individual discs 4-1/2 inches in diameter cut from the leaf lamina and stacked to a thickness of approximately 1/2-to 5/8-inch when compressed within the apparatus during a test. Three apparent densities were tested: 30, 35, and 40 lbs./cu. ft. The thermal conductivity of the laminated specimens was found to be significantly influenced by both moisture content and apparent density. Specific heat was found to be significantly influenced by moisture content. Thermal diffusivity was determined from the developed data. It is recommended that the equations devel-

oped be used to predict values of diffusivity as a function of the influencing factors. By this method, diffusivity was found to be essentially constant with a value of approximately .0029 ft.^{2}/hr. up to 50 percent moisture content (wet basis) regardless of apparent density. Above 50 percent, diffusivity increased rapidly and was also affected by different apparent densities.

Measuring the coloring rates of primed burley leaves with time-lapse photography. Basic information concerning tobacco responses to the curing environment was obtained under laboratory conditions. The colorating rate of leaves was measured by single-frame exposure of 16 mm color film at 1-hour intervals over periods from 4 to 12 days. Coloring rate was assumed to be directly related to curing rate for the samples tested. Tests were conducted at 80°, 90° and 100° F. with approximately the same leaf drying rate at each temperature (2 percent per hour dry weight basis). The leaf coloring rate increased significantly with temperature in the range 90° to 100° F., but not in the range 80° to 90° F. The time for complete leaf yellowing was about 300 hours at 80° F., 225 hours at 90° F., and 50 hours at 100° F. These results indicate the possibility of shortening the curing period by controlling the temperature at or near 100° F.

C. Electric Traps for Tobacco Insects

Laboratory investigations continued in cooperation with the Virginia Agricultural Experiment Station, Blacksburg, Virginia, on spectral response of hornworm moths to radiant energy bands centered at 3129, 3341, 3654, 4047, 4358, 4916, 5461, and 5780 Angstroms. Environmental conditions were maintained at a temperature of 75°F. and a relative humidity of 75%, Cooperation of ARS entomologists, Tobacco Experiment Station, Oxford, North Carolina, in furnishing laboratory-reared insects made it possible to conduct a more complete experiment than in previous years. The responses of insects to energy bands in the ultraviolet spectrum were significantly better than the responses to bands in the visible region.

Field tests were conducted at the Chatham, Virginia Tobacco Experiment Station on the effectiveness of lamp orientation and variations in the spectral output of blacklight fluorescent lamps for attracting insects. The vertical placement of lamps in comparison to those placed horizontally on traps again was more effective. No appreciable difference in the attractiveness of the lamps due to variations in the spectral output of the lamps was noted.

The field investigation to determine the effectiveness of blacklight insect traps for population control of tobacco hornworms was continued near Oxford, North Carolina, in cooperation with the Entomology Research Division, ARS. The hornworm population was extremely light during the season. Results obtained during the second year of operation of 324 traps in the 113-square-mile area showed a reduction in the tobacco hornworm population of about 80 percent. The corresponding reduction during the 1962 season was about 50 percent. A marked increase in stalk cutting in the trapped area in the fall of 1962 to

prevent late season breeding of hornworms contributed to the improved control in 1963. A limited number of traps equipped with fans were operated in the area. These appeared to be more effective in general for trapping corn earworm and tobacco budworm moths. Variations in trap design, including attractant lamp wattage and location, influenced the results. Efforts will be made to increase the area covered by traps during the 1964 season and to intensify work on trap design.

D. Radiofrequency Treatment of Tobacco Seed

Limited work on RF treatment of tobacco alkaloids to change chemical structure was continued in cooperation with the Crops Research Division, ARS. Additional evidence was obtained to indicate that RF treatment was effective in breaking down the ring structure of some alkaloids, where heat alone does not produce this result.

Earlier work with Crops Research Division treatment of tobacco seed with intense RF electric fields to produce genetic changes was prepared for publication.

Work on both of these studies is expected to be continued on a very limited basis.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

Tobacco Harvesting Equipment

Yoder, Elmon E. 1964. Palletizing burley proves its value. Western Tobacco Journal, Vol. 91, No. 2. Feb. pp. 14-15.

Electric Traps for Tobacco Insects

Lawson, F. R.; Gentry, C. R. and Stanley, J. M. 1963. Effect of light traps on hornworm population in large areas. ARS 33-91. Nov. 18 pp.

Radiofrequency Treatment of Tobacco Seed

Burk, L. G. and Nelson, S. O. 1964. Effects of radiofrequency electric fields on seeds of Nicotiana tabacum L. Crop Science. 4:100-103.

II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH

TOBACCO - COMPOSITION AND PROCESSING

Eastern Utilization Research and Development Division, ARS

Problem. Although neither food nor fiber, tobacco nevertheless is grown on about a million acres, and in seven states provided more farm cash receipts than any other field crop in 1960. The farm value is about $1.3 billion. This crop is unique in that it yields about $3.1 billion in Federal and State taxes. Several serious difficulties plague the industry, among them the lack of genuine scientific knowledge of the composition of tobacco and tobacco smoke, which can be used to solve many industrial problems. By knowing the chemical factors in the leaf which result in an acceptable smoke, it would become possible to predict accurately the usefulness of a particular tobacco for smoking purposes, and thus solve a long-standing industrial problem. Methods could also be devised to expedite current time-consuming and erratic methods of fermenting cigar tobacco. Finally, more selective studies on tobacco smoke could be made, including the origin and fate of leaf constituents during burning, the formation of substances having physiological effects, and ways of producing smoke of diverse composition.

USDA AND COOPERATIVE PROGRAM

The Department's continuing program involving chemists engaged in basic and applied studies of the chemical composition of tobacco leaf and smoke was directed to better understanding of and improvement in tobacco quality, and to improvement in tobacco processing technology. The direction of this program has been changed so as to place special emphasis on constituents which have been implicated in the smoking and health problem. The program now includes: (a) fundamental studies on the isolation and identification of chemical substances in cigarette leaf and smoke, (b) investigations on the combustion products of known constituents of cigarette tobaccos, and (c) studies on the elimination of deleterious substances in cigarette smoke through alteration of burning pattern and by selective filtration.

The Federal work is conducted at Wyndmoor, Pa., and Durham, N. C., and totals 10.7 professional man-years, 6.7 of which are devoted to study of the composition of tobacco smoke, mainly cigarette smoke, and 2.0 to composition of oxidation products and related substances, primarily of cigarette leaf. A research contract on chemical investigations of the neutral resins of tobacco leaf involving 2 professional man-years per year is under way at the Research Triangle Institute, Durham, N. C. In addition, the Cigar Manufacturers' Association of America supports a research program on cigar smoke at Wyndmoor, that is the equivalent of 2.0 professional man-years.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

A modest program of research related to the utilization of tobacco is conducted by the stations. Considerable effort is devoted to determining the effect of agronomic practices on the curing and fermentation process. The effect of chemical and microbiological changes during curing and fermentation

are also being investigated. In addition, development of analytical techniques for evaluation of tobacco characteristics receives some attention.

Study of curing methods, curing environments and the use of machines and machine methods in tobacco harvesting and processing is expanding. Research is also directed to the determination of the physical and chemical properties of tobacco; the composition of cigarette tobacco; and the chemistry of tobacco aroma and its source. In the study of tobacco aroma, major effort is devoted to collection of the volatile oils and their fractionation and identification.

The objective of work in progress at the Puerto Rico station is to determine standards of quality in tobacco and how best to carry out the fermentation and curing of tobacco leaves for cigar manufacture.

The total program involves 11.4 p.m.y.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Composition of Tobacco Smoke

1. Cigarette smoke. Further advances have been made in identifying the volatile constituents of cigarette tobacco leaf and smoke and in relating their presence to aroma and flavor variations. Four acids (n-butyric, n-heptylic, n-caprylic and n-pelargonic) were reported in cigarette tobacco leaf for the first time. Evidence was also obtained for the presence of the bases nicotinonitrile and metanicotine, and details were worked out for the isolation of 3-vinylpyridine from smoke. A total of thirty-two volatile bases were detected, the principal ones being pyridine, picolines, 3-vinylpyridine and nicotine.

The contribution of the various tobacco types to the flavor and character of blended cigarette tobacco was ascertained by a study of certain potentially flavorful volatile components in the smoke. An outgrowth of this was the development of a process to replace the Turkish tobacco in American cigarettes with domestic leaf to which has been added a mixture of isovaleric and β-methylvaleric acids which occur in comparatively large amounts in Turkish tobacco. The process merits consideration by industry, because tests indicate that the smoke flavor is indistinguishable from that of cigarette blends containing 5-20% Turkish tobacco.

2. Cigar smoke. The major volatile bases in cigar smoke have been isolated and identified as pyridine, 3-ethylpyridine, isomeric picolines, isomeric lutidines, 3-vinylpyridine, nicotine, nornicotine, myosmine and 2,3'-dipyridyl. The smoke of three commercial cigar brands contained similar amounts of the principal volatile bases (pyridine, picoline, 3-vinylpyridine). The smoke of typical domestic tobaccos contained less of the alkaloids (nicotine, especially) and more of the volatile bases (pyridine) than the smoke of "green" Brazilian tobaccos, reflecting the degree of fermentation.

Sufficient analytical data were obtained to compare the compositions of cigar and cigarette smoke on the basis of microgram per puff. The volatile acids were qualitatively similar, although cigarette smoke contained greater amounts of the C_2 - C_6 acids which are believed to contribute aroma to cigarette leaf and flavor to its smoke. The volatile bases were also similar and generally within the same range except that cigarette smoke contained higher concentrations of the alkaloids (nicotine, nornicotine-myosmine, etc.). Preliminary work on the neutral fractions indicates that cigar smoke contains at least 75 such components which may prove comparable to the neutral compounds of cigarette smoke.

B. Composition of Oxidation Products and Related Substances.

Fractionation studies to resolve the highly complex nature of the oxidation products of tobacco have led to the isolation of an interesting mixture of high molecular weight compounds from Turkish tobacco. This fraction accounts for a significant part of the leaf weight (about 3%) and resembles the dark pigments recently isolated by other workers and described as responsible for tobacco color. Preliminary work with this mixture showed that on hydrolysis it forms rutin, chlorogenic acid, amino acids and iron; on pyrolysis it produces more than 10 components which superficially resemble the pyrolytic products of rutin and other polyphenols. The nature of these breakdown products suggests that the newly isolated pigments may have a role in the generation of harmful and/or flavorful substances during burning.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Composition of Tobacco Smoke

Burdick, D., Schmeltz, I., Miller, R. L. and Stedman, R. L. 1963. Composition studies on tobacco. XIV. Steam-volatile, neutral substances in various types and grades. Tobacco Science, 7, pp. 97-100.

Burdick, D. and Stedman, R. L. 1963. Composition studies on tobacco. XV. Steam-volatile, neutral substances in smoke from blended and unblended cigarettes. Tobacco Science, 7, pp. 113-117.

Osman, S. R., Schmeltz, I., Higman, H., and Stedman, R. L. 1963. Volatile phenols of cigar smoke. Tobacco Science, 7, pp. 141-143.

Schmeltz, I., Miller, R. L. and Stedman, R. L. 1963. Gas chromatographic study of the steam-volatile fatty acids of various tobaccos. J. Gas Chromatog., 1, pp. 27-28.

Schmeltz, I., Stedman, R. L. and Miller, R. L. 1963. Composition studies on tobacco. XVI. Steam-volatile acids. J. Assoc. Offic. Agr. Chemists, 46, pp. 779-784.

Stedman, R. L. 1963. Arome, saveur et composition chimique du tabac et de la fumee de cigarette. CORESTA Bulletin d'information, No. 4, pp. 11-23.

Stedman, R. L., Burdick, D. and Schmeltz, I. 1963. Composition studies on tobacco. XVII. Steam-volatile acidic fraction of cigarette smoke. Tobacco Science, 7, pp. 166-169.

General

Ogg, C. L. 1964. Report on tobacco. J. Assoc. Offic. Agr. Chemists, 47, p. 49.

Ogg, C. L. and Cundiff, R. H. 1963. Determination of chlorides in tobacco. J. Assoc. Offic. Agr. Chemists, 46, pp. 415-418.

Ogg. C. L. and Cundiff, R. H. 1963. Determination of potassium in tobacco. J. Assoc. Offic. Agr. Chemists, 46, pp. 413-415.

Stedman, R. L. and Miller, R. L. 1963. Some pitfalls in studies related to gas chromatography. J. Chromatog., 11, pp. 409-411.

Steyermark, A., Alber, H. K., Aluise, V. A., Huffman, E. W. D., Jolley, E. L., Kuck, J. A., Moran, J. J., Ogg, C. L. and Pietri, C. E. 1963. Report on recommended specifications for microchemical apparatus. Van Slyke apparatus. Microchemical J., 7, pp. 233-246.

III. MARKETING AND ECONOMIC RESEARCH

TOBACCO - MARKET QUALITY

Market Quality Division, ARS

Problem. Stored tobacco and tobacco products are subject to insect damage that seriously affects the grade, value, and potential end use. The price support program has resulted in a large buildup of stocks, some held for as long as 7 years, about twice the normal period for storage and aging. The long-term storage and the compact, dense structure of the tobacco as stored in hogsheads make insect control difficult. Repeated, heavy applications of fumigants or other control measures during extended storage has raised a question as to the extent and significance of residues that may be accumulated. Treatments applied during storage should be assessed further to be sure they are safe. Measures now used only hold insect populations in check and do little to reduce them or prevent them from becoming established. Attention should be given to the development of measures that will minimize or eliminate the use of chemicals, and at the same time effectively eliminate or prevent infestations. To accomplish this it will be necessary to develop much more basic information than is now available on the ecology, physiology, and behavior of the insects that attack stored tobacco.

USDA PROGRAM

The Department has a continuing program at Richmond, Virginia, involving entomologists engaged in basic and applied research on the insect problems of stored tobacco and tobacco products in the marketing channels. The research is conducted in cooperation with farmers' cooperative associations, industry groups, and the Agricultural Stabilization and Conservation Service of this Department.

The Federal scientific effort devoted to research on prevention of insect infestation totals 3.3 professional man-years. In addition, some of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in stored tobacco.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Scientists of the State agricultural experiment stations are engaged in basic and applied research related to tobacco quality. Much attention is given to smoking quality, determination of varieties, and tobacco subjected to a wide range of management practices. Other basic studies

concern objective methods for determining smoking quality, the chemistry of curing, and fermentation processes to provide specific types of tobacco leaf, and the measurement of physical properties.

Use of machines and machine methods in tobacco harvesting and handling is expanding. Research is directed to determining the effects of mechanization procedures on quality. Work directed to devising new methods for the measurement of the chemical and physical properties of tobacco is of direct interest. These methods are applied in determining quality characteristics. The Puerto Rico station has a study on tobacco quality which is aimed at determining standards of quality in tobacco and correlating these with preferences of cigar smokers.

The total program involves 11.9 professional man-years for quality related research on tobacco.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Prevention of insect infestation

1. Basic Biology and Ecology. Tobacco moth larvae failed to mature at relative humidities of 30 and 40 percent when temperatures were 70 or 80° F. Some larvae lived for 5½ months before death, and were only half the size of normal larvae, which develop to adults in about 1 month. At relative humidities of 50 and 60 percent some larvae survived and matured to adults but their developmental period was 3 to 4 times longer than normal, and shorter at 80° than at 70° F. (MQ 1-7)

2. Insecticide Evaluation. Flue-cured tobacco at 14-percent moisture content accumulated more inorganic bromide residue during methyl bromide fumigation than did tobacco containing 10 percent moisture. The residue became progressively greater during 12 consecutive fumigations, and a 4-fold increase in dosage produced 3 to 4 times more residue. The tobacco did not develop any abnormal taste until after 10 fumigations at the rate of 16 ounces of methyl bromide per 1,000 cubic feet. When the rate was increased to the excessively high amount of 64 ounces, abnormal flavor was present after only 2 fumigations. (MQ 1-33)

A pulsating insect retention cage was designed and constructed to hold crawling and flying insects, especially the adult cigarette beetle, on a non-vibrating test surface without harming or adversely influencing the reactions of the test insects. Using this equipment it is now possible for the first time to conduct satisfactory residual toxicity and repellency tests with the cigarette beetle and such studies are now in progress. (MQ 1-35)

3. Insecticidal Control. Insecticide-coated kraft paper bands were placed around the middle of hogsheads of tobacco that were broken open

yearly for inspection. After 3 years of storage all hogsheads with bands coated with synergized pyrethrum were protected against insect damage in the "break;" 75 percent of the hogsheads with TDE or lindane on the bands were protected; and 25 percent of the hogsheads had no appreciable damage when there were no bands, untreated bands, or a combination of methoxychlor and synergized pyrethrum on the bands. (Exploratory)

4. Nonchemical Control. A small vacuum-steam chamber was designed and constructed to permit laboratory studies in which tobacco could be treated under better controlled conditions than with commercial equipment. Variable factors evaluated were temperature, amount of vacuum, and rate of steam flow. Mortality of all stages of the cigarette beetle was obtained in 25 minutes at 120° F. and in 1 minute at 140° F. There is indication that the treatment at sublethal levels adversely affects the reproductive capability of surviving adult beetles. (Exploratory)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Prevention of Insect Infestation.

Childs, Dana P. 1964. The effects of flowing steam in vacuum against the cigarette beetle. Abstract in Proceedings, Tobacco Research Workers' Conference, Columbus, Ohio, January 27-30, 1964.

Childs, Dana P. 1964. New pulsating cage tames lively insects. Agricultural Marketing 9(8): 3-4, August 1964.

Tenhet, Joseph N. 1964. Repellents for the cigarette beetle. Abstract in Proceedings, Tobacco Research Workers' Conference, Columbus, Ohio, January 27-30, 1964.

ECONOMICS OF MARKETING
Marketing Economics Research Division, ERS

Problem: Important shifts in the demand for tobacco and tobacco products and changes in processing technology have been generating new stresses in the tobacco industry. The response to changing needs has been uneven among various elements of the tobacco marketing system with some participants showing substantial advances in improvement of practices and methods. To assist producers and marketing firms to remain competitive, and to contribute to better industry performance, studies need to be carried out and results made available concerning possibilities of improving marketing efficiency, reducing costs, and achieving a better working knowledge of the economics of tobacco quality and pricing efficiency.

USDA PROGRAM

The Department has a continuing and timely research program addressed to problems identified with the economics of tobacco marketing. In fiscal year 1964, this research effort amounted to 2.9 professional man-years with the program divided among the three important problem areas as follows: structure, practices and competition, 0.5; product quality, 0.5; and margins, costs, and efficiency, 1.9 man-years.

Except for research contracts nearing completion on Kentucky burley auction markets and the Canadian auction system, research on tobacco marketing is performed by personnel in Washington, D. C. However, these agricultural economists communicate and work closely with personnel at State agricultural experiment stations interested in tobacco marketing research.

PROGRAM OF STATE EXPERIMENT STATIONS

Research projects at State stations cover three functional areas of marketing. These are concerned with various management practices, financial factors, and costs and efficiency in tobacco warehouse operations, structure of the Pennsylvania tobacco industry, operation of the auction market and auction warehouse facilities, and labor requirements in preparation of flue-cured tobacco for market.

A total of 3.1 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

I. Tobacco

A. Structure, Practices and Competition

1. A comparative analysis of the Canadian tobacco auction system and the Kentucky auction system reveals wide variations in operating costs. The

costs of operating the Canadian auction warehouses in 1963 averaged $5.83 per thousand pounds of tobacco sold. Similar costs for operating the Kentucky auction warehouses in 1959 averaged about $20.00 per thousand pounds of tobacco sold. The Canadian auction system uses only 3 warehouses, owned by the Ontario Flue-Cured Tobacco Growers Marketing Board, to market the entire flue-cured production. The volume of tobacco sold through each warehouse averages over one-half million pounds of tobacco per day. This volume makes automation and volume handling possible on many operations. In contrast to the Canadian auction, warehouses in Kentucky average less than 50 thousand pounds of tobacco per day.

B. Product Quality

1. A study of the tobacco quality literature reveals that this area of research is being greatly enlarged due to the impact of the smoking and health report. This Department has contracted for additional chemical studies on the neutral resins of tobacco. A report from the Eastern Utilization Laboratory indicates that certain chemically isolated aromatic factions correlate with the results of smoking test panels. With a view to a practical market sampling and quality testing, the measurement of total alkaloid content appears to be the most feasible. Along with the chemical tests, measurements for physical data are important components of the tobacco use value. The two most important physical variables are moisture content and filling power with an unknown degree of interaction to be determined. Future progress will explore the feasibility of correlating sample data for these variables with value.

C. Margins, Costs and Efficiency

1. Manufacturing margins range widened as a result of technological and other advances in the tobacco manufacturing industry. These advances have had a definite and pronounced effect on the domestic requirements and demand for cigar and cigarette tobaccos. The introduction of small sized cigars and the use of sheet or homogenized binder has reduced the quantity of tobacco needed to produce a given number of cigars. The shift to homogenized binder and the increased production of "short-filler" cigars has made possible the mechanization of more manufacturing operations of the cigar industry. The share of consumer expenditures for cigarettes received by the growers in 1962 was 4 percent lower than it was in 1946, and the tax share was 5 percent lower. The most important reason for the decline in the growers' share was the introduction of filter-tip cigarettes and the development of the homogenized tobacco sheet, both of which reduce the leaf tobacco requirements in manufactured cigarettes. This in turn tended to widen the manufacturing margin.

2. A new package for selling flue-cured tobacco has been market tested. Key features of the new method are uses of 38-by-38-inch and 30-by-30-inch wooden frames during packing and knitted paper to wrap the tobacco. Use

of the frame results in square packages of loose leaves. Tobacco is wrapped in paper sheet when the frame is removed. Paper covering, which replaces customary burlap or cotton, stays with the tobacco all the way to the processing plant.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Cockroft, Lindon U. and Brown, J. W. H. September 1964. Developing and market testing--an improved looseleaf tobacco package. ERS-189. pp. 13.

ECONOMIC AND STATISTICAL ANALYSIS
Economic and Statistical Analysis Division, ERS

Problem. Because supply and demand factors for tobacco and tobacco products are changing continuously, these factors must be regularly appraised and these appraisals disseminated to farmers, the trade, and other interested persons. The typical tobacco farmer cannot afford to collect and analyze the statistical and economic information that vitally affects his economic position. Economic facts and analyses must be provided on supplies, prices, production and consumption of tobacco and tobacco products, and the export-import trade. Proposals to modify existing tobacco programs must be analyzed to assist the evaluations of alternatives by administrators and Congress. In addition to the usual economic variables, analyses have to take into consideration the health-related aspects as they may pertain to consumption of tobacco products and utilization of tobacco leaf.

USDA AND COOPERATIVE PROGRAM

A. Commodity Situation and Outlook Analysis

This work involves 1.5 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of tobacco and tobacco products. Results of these analyses and findings of special studies are published quarterly in the Tobacco Situation and periodically in other publications. A comprehensive analysis of the tobacco situation is presented at the Annual Outlook Conference. Situation and outlook appraisals also are presented at meetings of tobacco grower organizations and trade groups. Special analyses are prepared on the probable effect of alternative proposed programs on the price, supply, consumption and exports of tobacco. Basic statistical series are developed, improved, maintained, and published for general use in statistical and economic analysis.

B. Supply, Demand and Price

This work involves 0.5 professional man-year located in Washington, D. C. The research effort is related to (1) economic factors affecting supply, price, and utilization of tobacco and tobacco products; and (2) economic effects of technological changes on supply, demand, utilization, and price of leaf tobacco. Under the first area of work, analyses are developed to measure the influence of factors affecting consumption of tobacco products, prices of major kinds of leaf tobacco, and exports. Under the second area of work, information and analyses are developed for evaluating the effects of consumption trends and of recent technological changes in tobacco manufacturing on supply, demand, and price of leaf tobacco. These changes are analyzed from the standpoint of immediate and long-range effects on growers, export markets, and tobacco programs. Results from both areas of work are used in program appraisals involving effects of alternative price support levels and marketing controls.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Commodity Situation and Outlook Analysis

In addition to the usual situation and outlook work, much time and effort were devoted to appraising economic implications of the smoking-health issue. Anticipating publication of the smoking-health report by the Surgeon General's Advisory Committee (published January 11, 1964), analysis was made of the impact of previous similar adverse reports, drawing on both U.S. and British experience. Since publication of the report, all available data bearing on the pattern of tobacco consumption have been analyzed and appraised. In the first quarter of 1964, cigarette consumption declined sharply but subsequently recovered considerably. Concurrent with the decline and partial recovery of cigarette consumption was a spurt in consumption of cigars and pipe-smoking tobacco. The 1964 cigarette consumption is estimated below 1963; consumption in 1965 and beyond will depend largely on consumer reaction to regulatory and educational actions that may be taken. Work was done on longer-term projections of tobacco consumption under varying assumptions. As a possible aid in projection work, arrangements weremade to obtain data from Public Health Service surveys on tobacco use and consumer attitudes. Proposed legislation bearing on cigarette smoking and health, and on tobacco price supports was analyzed.

B. Supply, Demand and Price

Some revisions were made in seasonal factors following further analysis of seasonality of manufactured tobacco and exports. Trends in utilization of tobacco as affected by recent technological changes were analyzed as to their impact on growers, and findings were included in situation and outlook reports. In 1963, use of tobacco in cigarettes is estimated to have increased about 1½ percent over 1962, whereas cigarette output increased 2.8 percent. Analysis was made of factors affecting snuff consumption. Review was made of the historical experience, both U. S. and British, following release of adverse health reports, in preparation for analyzing the economic impact of the smoking-health report of the Surgeon General's Advisory Committee. An analysis also was made of alternative methods of supply adjustment.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Conover, A. G. and Sackrin, S. M. Tobacco Situation. Published quarterly. ERS, USDA, Washington, D. C.